Proceedings of
the United States
National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 1967 Number 3573

MAR 1
LIBRARY

NEW CYCLOPOID COPEPODS ASSOCIATED WITH THE ALCYONARIAN CORAL TUBIPORA MUSICA (LINNAEUS) IN MADAGASCAR

By ARTHUR G. HUMES AND JU-SHEY HO

SMITHSONIAN PRESS

DEPOSITED BY THE
TED STATES OF AMERICA

Proceedings of
the United States
National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 1967 Number 3573

NEW CYCLOPOID COPEPODS ASSOCIATED WITH THE ALCYONARIAN CORAL TUBIPORA MUSICA (LINNAEUS) IN MADAGASCAR

By Arthur G. Humes and Ju-Shey Ho [1]

At Nosy Bé, in the northwestern part of Madagascar, several species of copepods (Humes and Frost, 1964) are known to be associated with members of the alcyonarian order Alcyonacea, but until now none have been reported living with members of the order Stolonifera.

While participating in the work of the U.S. Program in Biology of the International Indian Ocean Expedition at Nosy Bé in 1963–64, the first author collected 4 species of cyclopoid copepods from washings of *Tubipora musica* (Linnaeus), the common organ-pipe coral. These species are described below.

All figures have been drawn with the aid of a camera lucida.

The study of the material has been aided by a grant (GB–1809) from the National Science Foundation. We wish to thank Dr. Michel Pichon for verification of the identity of the coral and to acknowledge the many courtesies received from the staff of the Centre d'Océanographie et des Pêches at Nosy Bé.

[1] Both authors: Department of Biology, Boston University, Boston, Mass.

Family Lichomolgidae Kossmann, 1877

Genus *Lichomolgus* Thorell, 1860

Lichomolgus organicus, new species

FIGURES 1–30

TYPE MATERIAL.—207 ♀♀, 98 ♂♂, and 15 copepodids from a colony of *Tubipora musica* (Linnaeus), in 1 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Madagascar, collected June 8, 1964: holotype ♀ (USNM 113387), allotype (USNM 113388), and 144 paratypes (USNM 113389) (100 ♀♀ and 44 ♂♂) deposited in the United States National Museum, 80 paratypes (50 ♀♀ and 30 ♂♂) in the Museum of Comparative Zoology, Harvard University, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—All from *Tubipora musica* collected in 1964: 8 ♀♀ and 8 ♂♂, in 1 m, Pte. à la Fièvre, Nosy Bé, Jan. 5; 1 ♀, in 15 cm, Tany Kely, a small island south of Nosy Bé, Mar. 29; 4 ♀♀ and 8 ♂♂, in 1 m, Pte. Ambarionaomby, Mar. 31; 15 ♀♀ and 1 ♂, in 1 m, Pte. à la Fièvre, Apr. 15; and 14 ♀♀, in 2 m, Pte. Ambarionaomby, Sept. 27.

FEMALE.—Body (fig. 1) with moderately broad prosome. Body length (not including setae on caudal rami) 0.99 mm (0.92–1.05 mm) and greatest width (in middle of cephalosome) 0.49 mm (0.44–0.53 mm), based on 10 specimens. Ratio of length to width of prosome 1.5:1. Segment of first leg separated dorsally and laterally from head by a transverse furrow; lateral areas of this segment not expanded. Lateral areas of segments bearing legs 2 and 3 expanded and rounded posteriorly; those of segment of leg 4 smaller and somewhat truncated.

Segment of leg 5 (fig. 2) wider than long, 61μ x 133μ, with fifth legs borne laterally. Ventrally between this segment and the genital segment no apparent intersegmental sclerite. Genital segment (fig. 2) about as long as wide, 140μ x 142μ, in dorsal view expanded laterally in its midregion, posterior to which the segment is constricted so that its width at the posterior end is only 80μ. Areas of attachment of egg sacs located dorsolaterally on posterior part of expansions. Each area (fig. 3) with 2 naked setae, 12 and 13μ in length; posterior to the setae a small rounded sclerotized protuberance. Three postgenital segments, each without ornamentation except for a few surficial hairs (sensilla), 37μ x 67μ, 26μ x 55μ, and 28μ x 51μ, respectively, from anterior to posterior.

Caudal ramus (fig. 4) only a little elongated, 36μ x 24μ in greatest dimensions, or 1.5 times longer than wide. Length along inner edge

to innermost distal seta 23μ, along outer edge to base of lateral seta 23μ, and to base of outermost distal seta 33μ. Of the usual 6 setae, outer lateral seta naked and 66μ long; remaining 5 feathered: pedicellate dorsal seta 47μ, innermost distal seta 115μ, outermost distal seta 91μ, and the 2 long median terminal setae, both "pegged," 169μ (outer) and 200μ (inner), and inserted between dorsal (unornamented) and ventral (with marginal row of spinules) flaps. In addition, a minute hyaline setule dorsally near insertion of outermost distal seta. Two hairs on dorsal surface of ramus.

Dorsal surface of prosome and dorsal and ventral surfaces of urosome with a few minute hairs. Ratio of length of prosome to that of urosome about 2.1:1.

All ovigerous females observed with broken egg sacs (one shown in fig. 5).

Rostral area (fig. 6) moderately well formed. At level of bases of second antennae a small longitudinal sclerotized ridge between rostrum and anterior part of labrum.

First antenna (fig. 7) 7-segmented, with third segment showing ventrally a proximal sclerotized area suggesting an intercalary segment. Lengths of the segments, measured along their posterior nonsetiferous margins: 28μ (56μ along anterior margin), 95μ, 25μ, 50μ, 50μ, 37μ, and 22μ, respectively. Formula for armature: 4, 13, 6, 3, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. All setae naked.

Second antenna (fig. 8) 4-segmented, with last segment moderately elongated, 65μ along its outer edge, 39μ along its inner edge, and 27μ wide. Each of first 2 segments with a small inner seta, third segment with 3 setae (1 of them jointed), and last segment with 7 elements: 5 setae and 2 unequal recurved claws 45μ and 34μ long (measured along greatest axis). All setae naked.

Labrum (fig. 9) with 2 relatively short posteroventral lobes, free border of each lobe showing 2 small hyaline lamellae.

Mandible (fig. 10) with its basal region bearing on its posterior surface a small sclerotized area and separated by a constriction from its distal region, whose inner margin bears a prominent sclerotized pointed toothlike process followed by a striated fringe, whose outer margin has a row of slender spinules and which terminates in a long flagellum with lateral spinules. Paragnath (see fig. 9) a small lobe bearing inner hairs. First maxilla (fig. 11) a single segment bearing 2 terminal setae. Second maxilla (fig. 12) 2-segmented, first segment unarmed, second segment produced distally and bearing row of 4–5 teeth (compare figs. 12 and 13) and slender naked terminal process. (If 4 such teeth, distalmost often slightly bifurcated; if 5, teeth all entire.) On postero-inner surface of second segment 2 setae, one finely pectinate along one margin, other bearing long bluntly tipped

setules along one side. A minute setule on proximal outer edge of this segment. Maxilliped (fig. 14) 3-segmented. Two naked setae on second segment. Third segment (fig. 15) bearing a naked seta, a setiform element with bifurcated tip, and a terminal process about 22μ long and clawlike, with a small hyaline lobe on each side of distal point.

Postoral area (fig. 16) only slightly produced ventrally; an incomplete line of sclerotization between bases of maxillipeds.

Legs 1–4 (figs. 17–20) with trimerous rami except for 2-segmented endopod of leg 4. Armature of legs as follows (Roman numerals=spines, Arabic numerals=setae):

P 1	protopod	0:1	1:0	exp	I:0	I:1	III,I,4
				end	0:1	0:1	I,5
P 2	protopod	0:1	1:0	exp	I:0	I:1	III,I,5
				end	0:1	0:2	I,II,3
P 3	protopod	0:1	1:0	exp	I:0	I:1	III,I,5
				end	0:1	0:2	I,II,2
P 4	protopod	0:1	1:0	exp	I:0	I:1	II,I,5
				end	0:1	II	

Inner seta on coxa of legs 1–3 long and plumose, but in leg 4 short (17μ) and naked. In first 3 pairs of legs inner margin of basis with short row of hairs, but such hairs absent in leg 4. In all 4 legs setae on inner side of last segment of exopod with lateral hairs shorter proximally than distally. Spine on last segment of endopod of leg 1 24μ in length. Endopod of leg 4 shorter than exopod. First segment 33μ x 25μ with inner distal plumose seta 41μ long. Second segment 61μ long (including 2 terminal spinous processes) and 23μ wide in basal half and 19μ wide in distal half, the 2 halves demarcated by very slight indentation. Along outer margin of both segments rows of minute spinules. Terminally second segment with a row of minute spinules near insertion of 2 unequal spines, both with spinulose fringes, outer spine 21μ, inner 39μ long, ratio about 1:1.86.

Leg 5 (fig. 21) with free segment elongated and slightly arcuate in outline, 66μ x 23μ, with short stout spines along outer edge and extending around to distal ventral surface; bearing terminally 2 naked setae 35μ and 37μ in length. Seta on body near free segment slightly feathered with group of spines near its insertion.

Leg 6 probably represented by 2 setae near areas of attachment of each egg sac (see fig. 3).

Color in life in transmitted light rather translucid, eye red.

MALE.—Body (fig. 22) resembling in general form that of female. Length (excluding ramal setae) 0.89 mm (0.85–0.92 mm) and greatest width 0.32 mm (0.30–0.34 mm), based on 10 specimens. Ratio of length of prosome to that of urosome 1.6:1.

Segment of leg 5 (fig. 23) 29μ x 67μ. Genital segment longer than wide, 164μ x 122μ in greatest dimensions, and in dorsal view rather bottle shaped, its lateral borders gently rounded. No intersegmental sclerite ventrally between these 2 segments. Four postgenital segments 18μ x 45μ, 19μ x 43μ, 15μ x 40μ, and 17μ x 43μ, respectively, from anterior to posterior.

Caudal ramus (fig. 24) resembling that of female, but slightly less elongated, its greatest dimensions 31μ x 21μ, or 1.48 times longer than wide.

Surfaces of prosome and urosome with minute hairs as in female. Ratio of length of prosome to that of urosome 1.56:1.

Rostral area like that in female.

First antenna resembling that of female, but an aesthete added on segments 2 and 4 (at exact points indicated by arrows in fig. 7), so that formula is 4, 13+1 aesthete, 6, 3+1 aesthete, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. Second antenna (fig. 25) more slender than in female, and last segment elongated, 68μ along outer edge, 52μ along inner edge, and 15μ wide. First segment with inner crescentic row of small spinules. Second segment with numerous small spinules along inner surface, arranged in 2 groups proximal and distal to seta. Last segment with row of very small spinules along inner surface. Armature like that of female, but 2 claws more nearly equal in length (34μ and 35μ), though posterior claw more slender than other.

Labrum, mandible, paragnath, first maxilla, and second maxilla like those in female. Maxilliped (fig. 26) 4-segmented (assuming that proximal part of claw represents fourth segment). First segment unornamented. Second segment bearing on medial surface 2 setae and 2 rows of long spinules. Small third segment unarmed. Slender slightly recurved terminal claw 178μ in length (measured along axis), with narrow terminal lamella, smooth lamellar fringe along its concave surface, and 2 setae near its base, one on posterior surface 44μ long and finely barbed, other on anterior surface 17μ long, naked, and hyaline. Suggestion of division about midway along claw.

Postoral area resembling that of female.

Legs 1–4 resembling those in female and with same spine and setal formula, except for endopod of leg 1 (fig. 27), which has arrangement of 0:1; 0:1; I,I,4. On last segment of this endopod 2 spines, outermost of setae in female being here replaced by a spine; outer spine 29μ long, inner spine 43μ long and recurved distally, and both spines with strong lateral spinules. In alcoholized specimens last segment of endopod flexed outwardly. Terminal spines on endopod of leg 4 in one male 19μ (outer) and 51μ (inner), in another 16μ and 37μ, with an average of 17.5μ and 44μ, ratio of 1:2.5.

Leg 5 (fig. 28) with free segment elongated and slender, 36μ x 9μ, with nearly parallel sides in dorsal view, and with 2 terminal setae unequal, outer 31μ and inner 19μ long. Few minute spinules on outer distal surface of segment. No spinules near insertion of seta on body near free segment.

Leg 6 (fig. 29) a posterolateral flap on ventral surface of genital segment bearing 2 naked setae 23μ and 25μ long.

Spermatophore (fig. 30) inside body of male about 148μ x 68μ plus neck of 14μ.

Color in life resembling that of female.

ETYMOLOGY.—The specific name *organicus*, from Latin, relating to musical instruments, refers to the association of this species with the organ-pipe coral *Tubipora musica*.

COMPARISON WITH RELATED SPECIES.—Among those species in the large genus *Lichomolgus*, wherein the mandible has been described, there are 3 that, like *L. organicus*, show a prominent toothlike process on the proximal inner margin of this appendage. From these, *L. organicus* may be readily distinguished. In *L. actinophorus* Humes and Frost (1964) there is a single claw on the last segment of the second antenna, the free segment of leg 5 in the female is somewhat irregular and has a ratio of 2.1:1, the caudal ramus of the female has a ratio of 3.5:1, and there is a setiferous sphere on the second segment of the second maxilla. In *L. decorus* Humes and Frost (1964) there is one claw and one clawlike spine on the last segment of the second antenna, the last segment of the exopod of leg 4 has the formula III,I,5, and the free segment of leg 5 in the female is 2.2:1 with a basal expansion. In *L. protulae* Stock (1959) the shape of the body is transformed, there are 3 strong claws and 2 setiform claws on the last segment of the second antenna, the caudal ramus of the female has a ratio of about 8.3:1, the free segment of leg 5 in the female is about 2.1:1, and the toothlike process on the mandible is directed distally rather than proximally as in *L. organicus*. In addition, the females of *L. actinophorus* and *L. protulae* are distinctly larger.

There are 8 species of *Lichomolgus* in which the form of the mandible is unknown. These may be separated from *L. organicus*, however, on the basis of other characters (in each case using the female, except in the last mentioned species where the female is unknown). In *L. dentipes* Thompson and A. Scott (1903) the formula for the last segment of the exopod of leg 4 is III,I,5 and the free segment of leg 5 has a prominent toothlike inner process. In *L. elegans* Thompson and A. Scott (1903) there is 1 claw on the second antenna and the body is larger (1.5 mm) and more slender. In *L. gigas* Thompson and A. Scott (1903) there is one claw on the second antenna and the body is larger (2 mm). In *L. longipes* (Sewell, 1949) leg 5 is very long (about

8:1) and the body is larger (1.63 mm) and more slender. In *L. rigidus* Ummerkutty (1962) the formula for the last segment of the exopod of leg 4 is III,I,5 and the body is larger (1.25 mm). In *L. rotundus* Sewell (1949) the free segment of leg 5 is short, swollen, and somewhat produced on the outer margin, with a ratio of about 2:1. In *L. tenuicornis* Brady (1910) the caudal ramus is about 7:1, the free segment of leg 5 has a small basal expansion, and the body is larger (1.7 mm). In *L. vagans* Gurney (1927) (based on the male), the body is larger (1.07 mm) and the last segment of the second antenna (Gurney, 1927, p. 466, fig. C) has a ratio of length of the outer margin to width of about 5.6:1, thus being slightly more slender than in *L. organicus*, where the ratio is about 4.5:1.

Since we still do not know the taxonomic importance of the variation in many characters observed in *Lichomolgus* (such as the terminal armature of the second antenna, the armature of the exopod of leg 4, the exact form of the mandible and leg 5, etc.), we find it impossible in *Lichomolgus* to say with which species *L. organicus* is most closely related. Such a conjecture would seem to be premature in view of the apparent very incomplete knowledge of the species in this genus.

Lichomolgus conjunctus, new species

FIGURES 31–36

TYPE MATERIAL.—163 ♀♀ and 25 ♂♂ from a colony of *Tubipora musica* (Linnaeus), in 1 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Madagascar, collected June 8, 1964: holotype ♀ (USNM 113391), allotype (USNM 113392), and 89 paratypes (USNM 113393) (79 ♀♀ and 10 ♂♂) deposited in the United States National Museum, 45 paratypes (40 ♀♀ and 5 ♂♂) in the Museum of Comparative Zoology, Harvard University, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—All from *Tubipora musica* collected in 1964: 121 ♀♀ and 53 ♂♂, in 1 m, Pte. à la Fièvre, Nosy Bé, Jan. 5; 9 ♀♀, in 15 cm, Tany Kely, a small island south of Nosy Bé, Mar. 29; 8 ♀♀, in 1 m, Pte. Ambarionaomby, Nosy Komba, Mar. 31; 14 ♀♀ and 3 ♂♂, in 1 m, Pte. à la Fièvre, Apr. 15; and 43 ♀♀, in 2 m, Pte. Ambarionaomby, Sept. 27.

In the description that follows, morphological features not specifically mentioned may be assumed to be essentially like those in *L. organicus*.

FEMALE.—Body (fig. 31) with prosome more pointed anteriorly than in *L. organicus*. Length of body (without ramal setae) 0.80 mm (0.72–0.87 mm) and greatest width 0.38 mm (0.34–0.40 mm), based on 10 specimens. Ratio of length to width of prosome 1.53:1.

Segment of leg 5 (fig. 32) 46μ x 107μ. Genital segment slightly wider than long, 110μ x 115μ, in dorsal view expanded laterally just behind its midregion, posterior to which segment is constricted, with width at posterior end of segment 60μ. Each area of attachment of egg sacs, located dorsolaterally on expanded part of segment, bearing 2 naked setae and rounded protuberance (more prominent than in previous species). Three postgenital segments 25μ x 53μ, 21μ x 48μ, and 23μ x 46μ, respectively, from anterior to posterior.

Caudal ramus (fig. 33) only slightly longer than wide, 28 $\times$ 23μ in greatest dimensions, ratio of length to width 1.22 : 1. Length along inner edge to innermost distal seta 19μ, along outer edge to base of lateral seta 19μ and to base of outermost distal seta 25μ. Pedicellate dorsal seta apparently naked. Relative lengths of 6 setae approximately those of *L. organicus*.

Ratio of length of prosome to that of urosome 2.6 : 1.

Egg sacs on all ovigerous females broken.

Rostral area (fig. 34) slightly more elongated posteriorly than in *L. organicus*. Segments of first antenna 23μ (44μ), 97μ, 21μ, 46μ, 45μ, 31μ, and 20μ in length (measured as before) and arrangement of naked setae and aesthetes as in previous species. Second antenna resembling that of *L. organicus*, but last segment slightly more slender (63μ along its outer edge, 39μ along its inner edge, and 21μ wide). Larger claw 37μ long, and more slender claw 32μ in length.

Labrum, mandible, paragnath, and first maxilla like those in *L. organicus*. Second maxilla closely resembling that species also, but pectinate seta on second segment slightly longer, reaching nearly to end of first tooth; in females studied 4–5 entire teeth, or 4 teeth with distalmost slightly bifurcated. Maxilliped resembling that of *L. organicus*, but subterminal setiform element apparently not as distinctly bifurcated at its tip.

Postoral area similar to that in previous species.

Legs 1–4 with same segmentation and spine and setal formula as in *L. organicus*. Spine on last segment of endopod of leg 1 27μ long. Endopod of leg 4 (fig. 35) with the following dimensions: first segment 33μ x 25μ with inner seta 40μ long, second segment 60μ x 21μ (greatest width) and 18μ (least width) with 2 terminal spines 25μ (outer) and 54μ (inner) in length, the ratio about 2.16:1.

Leg 5 similar to that of *L. organicus*, dimensions of free segment about 63μ x 24μ.

Leg 6 (represented by 2 setae near attachment of egg sacs) like that in previous species.

Color in life resembling that of *L. organicus*.

MALE.—Body (fig. 36) with prosome more pointed than in previous species. Body length (excluding setae on caudal rami) 0.71 mm (0.65–0.76 mm) and greatest width 0.27 mm (0.23–0.30 mm), based on 10 specimens. Ratio of length of prosome to its width 1.5:1.

Segment of leg 5 25μ x 66μ. Genital segment 151μ x 117μ. Four postgenital segments 14μ x 45μ, 16μ x 42μ, 13μ x 40μ, and 17μ x 42μ, respectively, from anterior to posterior. Caudal ramus 25μ x 21μ, or 1.19:1. Ratio of length of prosome to that of urosome 1.57:1.

TABLE 1.—*Comparison of certain features of* Lichomolgus organicus *and* L. conjunctus

Characters	*L. organicus*	*L. conjunctus*
Female		
body size	0.99 x 0.49 mm	0.80 x 0.38 mm
anterior border of prosome	rounded	more pointed
ratio of prosome to urosome	2.1:1	2.6:1
caudal ramus	36μ x 24μ (1.5:1)	28μ x 23μ (1.22:1)
genital segment	lateral indentations near middle (fig. 2)	lateral indentations further back (fig. 32)
second antenna	last segment 27μ wide, claws 45μ and 34μ	last segment 21μ wide, claws 37μ and 32μ
spine on last segment of endopod of leg 1	24μ	27μ
spines on last segment of endopod of leg 4	21μ and 39μ (1:1.85)	25μ and 54μ (1:2.16)
Male		
body size	0.89 x 0.32 mm	0.71 x 0.27 mm
anterior border of prosome	rounded	more pointed
caudal ramus	31μ x 21μ (1.48:1)	25μ x 21μ (1.19:1)
spines on last segment of endopod of leg 4	17.5μ and 44μ (1:2.5)	18μ and 50μ (1:2.8)
free segment of leg 5	36μ x 9μ (4:1)	28μ x 8μ (3.5:1)

Rostral area like that of female. First antenna resembling that of *L. organicus*, with same formula for setae and aesthetes. Second antenna also resembling that species; last segment 73μ along outer edge, 54μ along inner edge, and 14μ wide. Two claws (34μ and 35μ) similar to those in *L. organicus*.

Labrum, mandible, paragnath, first maxilla, and second maxilla like those in female; in males observed 4 teeth on distal end of second

maxilla, last tooth slightly bifurcated or entire. Maxilliped and postoral area much like those in *L. organicus*.

Legs 1–4 resembling those of female with same spine and setal formula, except for sexual dimorphism in leg 1 (as in *L. organicus*). Two spines on last segment of endopod of leg 1 like those in previous species, outer 27μ and inner 40μ long. Two terminal spines on endopod of leg 4 18μ (outer) and 50μ (inner), ratio of 1:2.8.

Leg 5 resembling that of *L. organicus*, but free segment relatively slightly shorter, 28μ x 8μ.

Leg 6 similar to that in previous species, but 2 naked setae slightly longer (28μ).

Spermatophores, seen only inside body of male, resembling those of *L. organicus*.

Color in life like that of female.

ETYMOLOGY.—The specific name *conjunctus*, from Latin, meaning "closely related or bordering on," refers to the close similarity between this and the preceding species.

COMPARISON WITH RELATED SPECIES.—*L. conjunctus* closely resembles *L. organicus* in general appearance, but a careful study shows certain constant and characteristic differences. These are summarized in table 1.

ASSOCIATION OF THE TWO LICHOMOLGIDS WITH THE ALCYONARIAN.—Both *L. organicus* and *L. conjunctus* were recovered after washing unbroken colonies of *Tubipora musica* in sea water to which about 5 per cent ethyl alcohol had been added. The exact habitat of the copepods is unknown, but there seems to be little doubt of their association with the alcyonarian in view of the large numbers of individuals recovered.

Family Clausidiidae Embleton, 1901

Genus *Hippomolgus* Sars, 1917

Hippomolgus latipes, new species

FIGURES 37–58

TYPE MATERIAL.—8 ♀♀ from a colony of *Tubipora musica* (Linnaeus), in 1 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Madagascar, collected Mar. 31, 1964: holotypic ♀ (USNM 113395) and 4 paratypic ♀♀, (USNM 113396) deposited in the United States National Museum; remaining 3 ♀♀ (dissected) in the collection of A. G. Humes.

OTHER MATERIAL.—Also from *Tubipora musica*: 1 ♀, in 1 m, Pte. Ambarionaomby, Nosy Komba, June 8, 1964.

FEMALE.—Body (fig. 37) with a rather harpacticoid appearance. Length (excluding setae on caudal rami) 1.13 mm (0.97–1.19 mm)

and greatest width 0.32 mm (0.27–0.37 mm), based on 8 specimens. Ratio of length to width of prosome 1.65:1. Segment bearing leg 1 completely fused with head. Lateral areas of segments of legs 1–3 not produced; those of segment of leg 4 slightly angular posteriorly.

Segment of leg 5 (fig. 38) broad, 94μ x 242μ, with fifth legs borne posterolaterally. Between this segment and genital segment on ventral side a weak intersegmental sclerite. Genital segment (fig. 38) wider than long, 130μ x 198μ. In ventral view its lateral border (fig. 39) with a small notch near middle of segment and a more pronounced indentation posteriorly. Areas of attachment of egg sacs situated dorsolaterally in midregion of segment. Each area (fig. 40) bearing outwardly a rather hyaline flange and inwardly a slender seta 11μ long, a spiniform seta 8μ long, and 2 small spinous processes. On ventral surface of posterior half of genital segment a transverse row of prominent spinules. Three postgenital segments 78μ x 135μ, 60μ x 118μ, and 91μ x 91μ, respectively, from anterior to posterior. Anal segment (fig. 41) bearing anteriorly 4 transverse rows of spinules, 2 rows ventrolateral and 2 ventral; along its posterior border near insertion of each caudal ramus a row of small spinules, this row continued on dorsal side.

Caudal ramus (fig. 42) 104μ x 34μ, or 3 times longer than wide. Minute basal outer spinule 3μ long. Outer lateral seta 22μ long and naked. Outermost terminal seta 41μ long, naked, and composed of 2 parts: a sclerotized proximal half and a more slender distal portion. Innermost terminal seta 57μ long and haired along inner side. Two long terminal setae 209μ (outer) and 462μ (inner), both basally "pegged" and bearing lateral spinules. Pedicellate dorsal seta 39μ long and naked. Dorsal surface of ramus with small hairs and refractile points as indicated in figure.

Dorsal surface of prosome and dorsal and ventral surfaces of urosome with scattered refractile points and hairs. Prosome slightly longer than urosome, ratio 1.1:1.

In single ovigerous female collected egg sac (fig. 43) 319μ x 107μ, extending a little beyond ends of caudal rami, with each egg about 40μ in diameter.

Rostral area (fig. 44) small and well sclerotized. Posterior to it, between bases of second antennae, a small circular sclerotization.

First antenna (fig. 45) 6-segmented and relatively short and robust, its length about 143μ. Lengths of segments measured along their posterior nonsetiferous margins: 15μ (39μ along anterior margin), 19μ, 28μ, 18μ, 13μ, and 24μ, respectively. First segment with 5 setae, proximal one lightly haired, distal one spiniform, with a row of scalelike spinules along one edge. On second segment 2 similar spiniform setae. All remaining setae naked. Each of last 3 seg-

ments with long prominent aesthete. Formula for armature: 5, 14, 9, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. Only ornamentation on first antenna consisting of crescentic row of spinules on first segment.

Second antenna (fig. 46) 4-segmented, last segment 32μ x 19μ in greatest dimensions. Each of first 2 segments with a seta, third segment with a spine and 2 slender setae on its inner distal expansion, and last segment bearing 7 elements (a spine and 6 setae). Ornamentation indicated in figure, inner margins of third and fourth segments having rows of scalelike spinules.

Labrum (figs. 47, 48) ornamented with spinules as indicated in figures.

Mandible (fig. 49) bearing 3 terminal elements: a clawlike ventral (outer) spine with 1–2 spinous processes on its concave edge, a spine with lateral spinous projections on its basal half, and a slender barbed seta. No paragnath. First maxilla (fig. 50) bilobed, with 8 setae disposed in groups of 3, 4, and 1. Second maxilla (fig. 51) 2-segmented; first segment unarmed, second with outer haired seta and 2 inner barbed spinulose setae and terminating in a short clawlike process with at either side a setiform barbed process (these 2 processes perhaps setae but their articulation not evident). Maxilliped (fig. 52) 4-segmented, first segment with inner barbed seta, second with 2 naked setae, third unarmed, and fourth (fig. 53) subterminally with small naked seta and terminally with minute spiniform process and fringe of spiniform ornamentations resembling a small fan.

Area behind mouth and between mouthparts (fig. 47) showing anteriorly a transversely elongated median lobe (lingua) with a few very minute lateral spinules, followed immediately by a transverse row of hairs in 2 groups. Posterior to this a row of prominent spinules, with at either end a cluster of hairs. Bases of maxillipeds joined by sclerotized lines. Postoral area between maxillipeds and leg 1 broadly protuberant, especially noticeable in lateral view.

Legs 1–4 (figs. 54–57) with 3-segmented rami. Armature of legs as follows (Roman numerals=spines, Arabic numerals=setae):

P 1	protopod	0:1	1:I	exp	I:0	I:1	III,I,4
				end	0:1	0:1	I,3
P 2	protopod	0:1	1:0	exp	I:0	I:1	III,I,5
				end	0:1	0:2	II,I,3
P 3	protopod	0:1	1:0	exp	I:0	I:1	III,I,5
				end	0:1	0:2	II,II,2
P 4	protopod	0:1	1:0	exp	I:0	I:1	II,I,5
				end	0:1	0:2	II,II,1

Free edges of all 4 intercoxal plates with rows of long slender setules. Inner margin of basis of leg 1 (fig. 54) bearing spinulose

spine 25μ long, with near its insertion an outer row of spinules and an inner spiniform process with slightly bifurcated tip. In legs 2–4 this margin more or less rounded and carrying only a row of hairlike setules. Terminal segment of endopod of leg 1 with 1 spine and 3 setae. Spinous processes at each side of insertion of spine either entire or bifurcated at tip. Ornamentation of legs indicated in figures.

Leg 5 (fig. 58) having an expanded free segment 83μ x 53μ in greatest dimensions. Four elements borne on this segment consisting (from dorsal to ventral) of a finely barbed spine 39μ long, a naked seta 66μ long, a strong spinulose spine 44μ long, and a short weakly barbed spine 23μ in length. Along dorsal edge of segment a row of spinules. Seta borne on body dorsal to insertion of segment 40μ long and naked. (In dorsal or ventral view of undissected animal, segment of leg 5 appearing much less expanded than actually.)

Leg 6 probably represented by seta and spine near attachment of each egg sac (see fig. 40).

Color in life unknown.

MALE.—Unknown.

ETYMOLOGY.—The specific name *latipes*, from Latin, meaning "having broad feet," refers to the wide free segment of leg 5 in this species.

COMPARISON WITH RELATED SPECIES.—Only a single species of the genus *Hippomolgus*, *H. furcifer* Sars (1917), has been known until now. This species was described on the basis of 3 females found free in 60 fathoms, muddy bottom, on the coast of Norway. Males of *Hippomolgus* are unknown, although Nicholls (1944, p. 46) has expressed the view that the male of *Hersiliodes dubia* Thompson and A. Scott (1903) is in reality a *Hippomolgus*. This opinion was followed by Krishnaswamy (1953), who reported males of *Hippomolgus dubia* from the plankton of Madras. It seems improbable to us, however, that *Hersiliodes dubia* is a *Hippomolgus*. The mandible, described by Thompson and Scott as having "2 horizontal plumose projections and 2 plumose setae," is very different. Bocquet and Stock (1957) think it probable that a new genus should be created for *Hersiliodes dubia*.

Like *Hippomolgus furcifer*, *H. latipes* has a body form that is less cyclopoid and more harpacticoid, has a relatively short 6-segmented first antenna with a prominent aesthete on each of the last 3 segments, lacks paragnaths, and has a generally similar structure of the second antennae, mouthparts, and legs 1–5.

There are, however, important differences between these 2 species (based of necessity on the female only). In *H. latipes* the first segment of the first antenna does not bear a spine such as described in *H. furcifer*. The mandible bears 3 terminal elements (2 spines and

1 seta) instead of 4, as in Sars' figure (pl. 82, m). The maxilliped is 4-segmented, the last segment ornamented with a small fanlike fringe, instead of being 3-segmented as in Sars' figure (pl. 82, mp^3). The armature of the last segment of the endopod of leg 1 is I,3 instead of I,II,3 as in Sars' species. The free segment of leg 5 is expanded instead of being narrow as in *H. furcifer*. The caudal ramus is only 3 times longer than wide instead of about 13:1 as in the Norwegian species. The length of the female is 1.13 mm, instead of 1.40 mm as in *H. furcifer*.

Hippomolgus cognatus, new species

FIGURES 59–69

TYPE MATERIAL.—Holotype ♀ (USNM 113397) from a colony of *Tubipora musica* (Linnaeus), in 1 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Madagascar, collected Mar. 31, 1964, deposited in the United States National Museum.

OTHER MATERIAL.—2 ♀♀ from *Tubipora musica*, in 1 m, Pte. à la Fièvre, Nosy Bé, Jan. 5, 1964, 1 ♀ (USNM 113398) in the United States National Museum, the other (dissected) in the private collection of A. G. Humes.

FEMALE.—Body (fig. 59) resembling that of *H. latipes*. Length (not including setae on caudal rami) 0.90 mm (0.82–0.95 mm) and greatest width 0.29 mm (0.28–0.31 mm), based on 3 specimens. Ratio of length to width of prosome 1.56:1.

Segment of leg 5 broad, 78μ x 188μ. Genital segment (fig. 60) only slightly wider than long, 120μ in length, 132μ wide in its anterior half, and 110μ wide in its posterior half, where sides in dorsal view are nearly parallel. Areas of attachment of egg sacs located dorsolaterally on midregion of segment. Each area (fig. 61) with a slender naked seta 22μ long, a spine 8μ long, and 2 spinous processes. Three postgenital segments 66μ x 101μ, 60μ x 91μ, and 80μ x 82μ, respectively, from anterior to posterior.

Caudal ramus (fig. 62) 64μ x 31μ in greatest dimensions, or 3 times longer than wide. Outer lateral seta 25μ, outermost terminal seta 39μ, innermost terminal seta 88μ, 2 long terminal setae 220μ (outer) and 450μ (inner), dorsal seta 33μ long.

Ratio of prosome to urosome 1.17:1.

In single ovigerous female collected egg sac (fig. 63) 352μ x 138μ, reaching nearly to ends of caudal rami, with each egg about 47μ in diameter.

Rostral area (fig. 64) bearing 2 rows of minute denticles.

First and second antennae like those in *H. latipes*. Labrum (figs. 65, 66) ornamented as indicated in figures. Mandible (fig. 67) bearing 3 terminal elements as in *H. latipes*, but these with different orna-

mentation, i.e., with spinous processes on both sides of 2 spines and with seta naked. Paragnath absent. First and second maxillae and maxilliped like those in *H. latipes*.

Area behind mouth and between mouthparts with median lobe (lingua) weakly developed. Postoral area between maxillipeds and leg 1 (fig. 65) less protuberant than in *H. latipes*.

Legs 1–4 with same spine and setal formula as in *H. latipes*, except for endopod of leg 1 being 0:1; 0:1; I,4. Leg 1 (fig. 68) with inner spine on basis 22μ long and adjacent spiniform process asymmetrically bifurcated; terminal segment of endopod with 4 setae and with 3 small and rather obtuse processes between spine and first seta. Legs 2–4 resembling those of *H. latipes*.

Leg 5 (fig. 69) with relatively slender free segment, 61μ along inner and ventral margin, 51μ along outer and dorsal margin, and 22μ wide. Armature from dorsal to ventral consisting of spine 21μ, seta 50μ, spine 25μ, and spine 40μ in length, all ornamented as in figure.

Leg 6 probably represented by spine and seta near attachment of each egg sac (see fig. 61).

In other respects similar to *H. latipes*.

Color in life unknown.

MALE.—Unknown.

ETYMOLOGY.—The specific name *cognatus*, from Latin, meaning "related or closely allied," refers to apparent close relationship between this species and *H. latipes*.

COMPARISON WITH RELATED SPECIES.—*H. cognatus* differs from *H. furcifer* Sars (1917) in lacking a spine such as described on the first segment of the first antenna in the Norwegian species, in having 3 terminal elements instead of 4 on the mandible, in having a 4-segmented maxilliped with a terminal fanlike fringe, in having the last segment of the endopod of leg 1 armed as I,4 instead of I,II,3 as in Sars' species, and in having a relatively much shorter caudal ramus, 3:1 instead of 13:1 as in *H. furcifer*. The length of the female is 0.90 mm instead of 1.40 mm as in the species described by Sars.

H. cognatus apparently is closely related to *H. latipes* but differs from it chiefly in the form of the genital segment, the presence of denticles on the rostral area, the form and ornamentation of the labrum, the ornamentation of the 3 elements on the mandible, the armature of the last segment of the endopod of leg 1, and the form of the free segment of leg 5.

ASSOCIATION OF THE TWO CLAUSIDIIDS WITH THE ALCYONARIAN.—Whether *Hippomolgus latipes* and *H. cognatus* live in a close association with *Tubipora musica* or occur only sporadically in the coral colony

is difficult to determine on the basis of the relatively few specimens collected. (No *Hippomolgus* were found in 4 other colonies of *Tubipora musica*.)

Literature Cited

BOCQUET, C., and STOCK, J. H.
1957. Copépodes parasites d'invertébrés des côtes de France, 1: Sur deux genres de la famille des Clausidiidae, commensaux de mollusques: *Hersiliodes* Canu et *Conchyliurus* nov. gen. Proc. Koninkl. Nederlandsche Akad. Wetensch. Amsterdam, ser. C, vol. 60, no. 2, pp. 212–222.

BRADY, G. S.
1910. Die marinen Copepoden der Deutschen Südpolar-Expedition 1901–1903, 1: Über die Copepoden der Stämme Harpacticoida, Cyclopoida, Notodelphyoida und Caligoida. No. 5 *of* vol. 11 (Zool. vol. 3) *in* Deutsche Südpolar-Expedition 1901–1903, pp. 497–593.

GURNEY, R.
1927. Zoological results of the Cambridge expedition to the Suez Canal, 1924, XXXIII: Report on the Crustacea: Copepoda (Littoral and semiparasitic). Trans. Zool. Soc. London, vol. 22, no. 4, pp. 451–577.

HUMES, A. G., and FROST, B. W.
1964. New lichomolgid copepods (Cyclopoida) associated with alcyonarians and madreporarians in Madagascar. Cah. O.R.S.T.O.M. Océanogr., Sér. Nosy-Bé, vol. 2, no. 6, pp. 131–212.

KRISHNASWAMY, S.
1953. Pelagic Copepoda of the Madras coast. Journ. Madras Univ., vol. 23 B, no. 1, pp. 61–75.

NICHOLLS, A. G.
1944. Littoral Copepoda from South Australia, II: Calanoida, Cyclopoida, Notodelphyoida, Monstrilloida and Caligoida. Rec. South Australian Mus., vol. 8, no. 1, pp. 1–62.

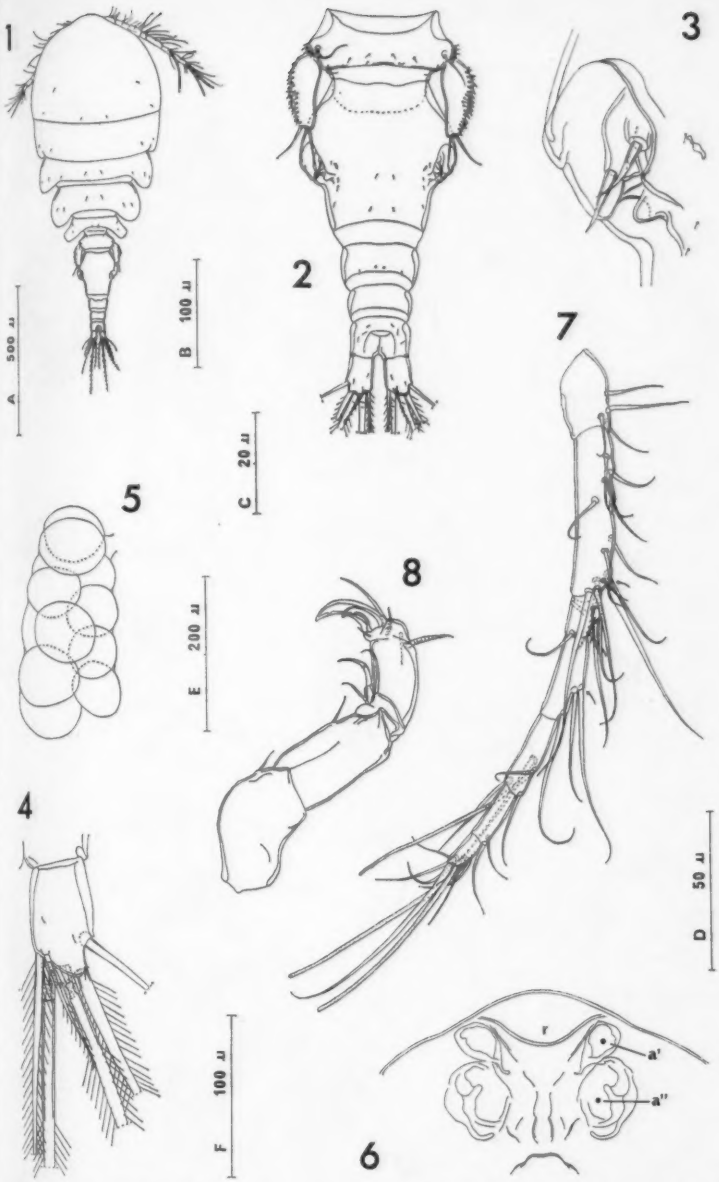
SARS, G. O.
1917. Clausidiidae, Lichomolgidae (part). Pts. 11 and 12 *of* vol. 6 (Copepoda, Cyclopoida) *in* An account of the Crustacea of Norway with short descriptions and figures of all the species, pp. 141–172.

SEWELL, R. B. S.
1949. The littoral and semi-parasitic Cyclopoida, the Monstrilloida and Notodelphyoida. No. 2 *of* vol. 9 *in* John Murray Expedition 1933–34 Scientific Reports, pp. 17–199.

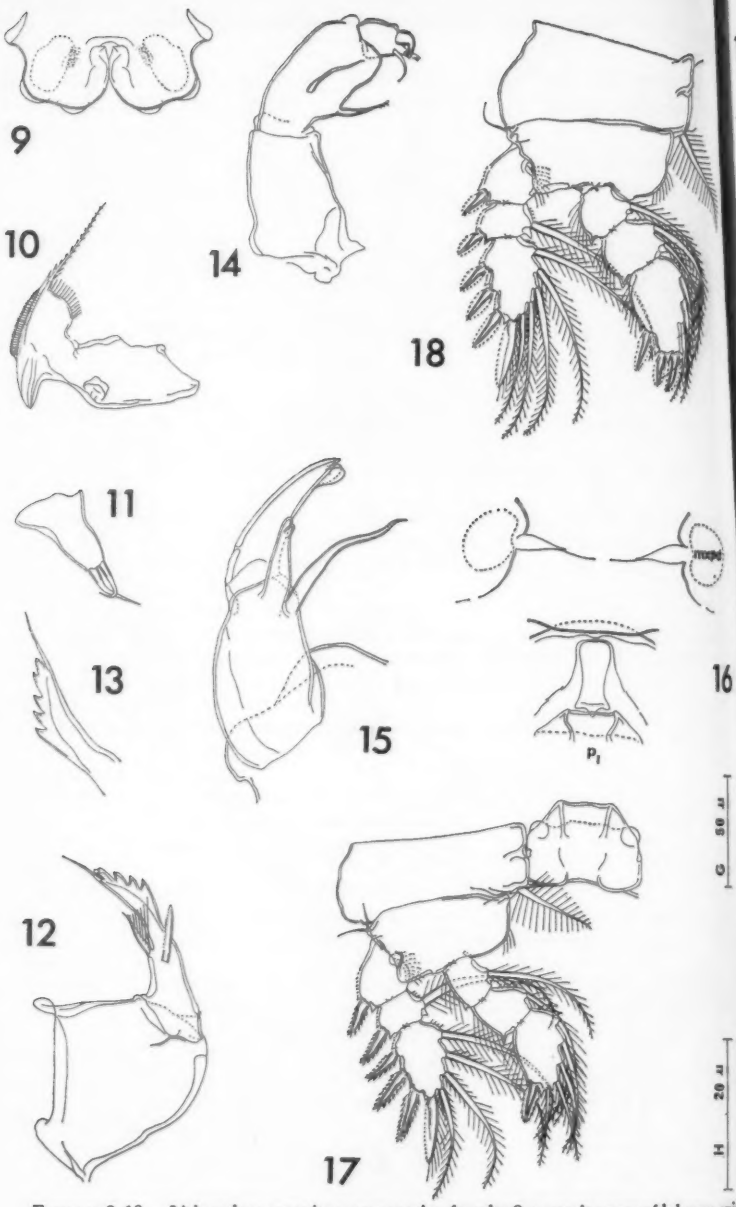
STOCK, J. H.
1959. Copepoda associated with Neapolitan invertebrates. Pubbl. Staz. Zool. Napoli, vol. 31, no. 1, pp. 59–75.

THOMPSON, I. C., and SCOTT, A.
1903. Report on the Copepoda collected by Professor Herdman, at Ceylon, in 1902. Rep. Gov. Ceylon Pearl Oyster Fish. Gulf of Manaar, suppl. rep., no. 7, pp. 227–307.

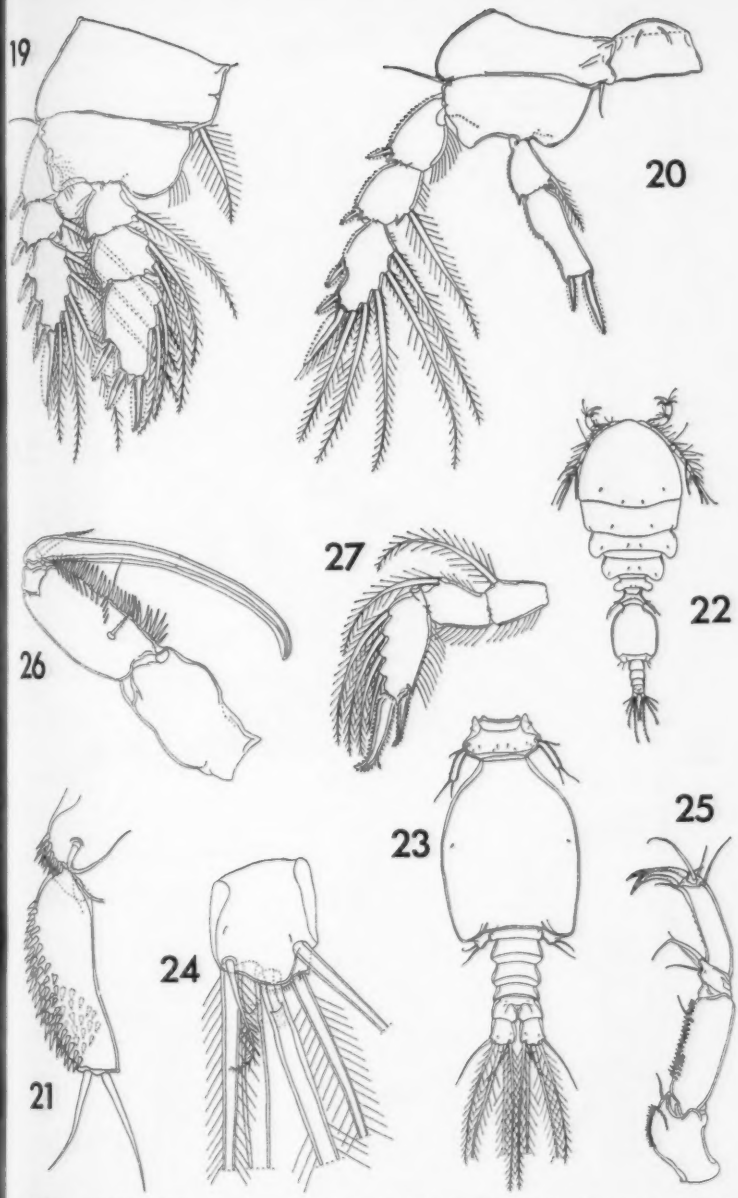
UMMERKUTTY, A. N. P.
1962. Studies on Indian copepods, 5: On eleven new species of marine cyclopoid copepods from the south-east coast of India. Journ. Mar. Biol. Assoc. India, 1961, vol. 3, nos. 1 and 2, pp. 19–69.



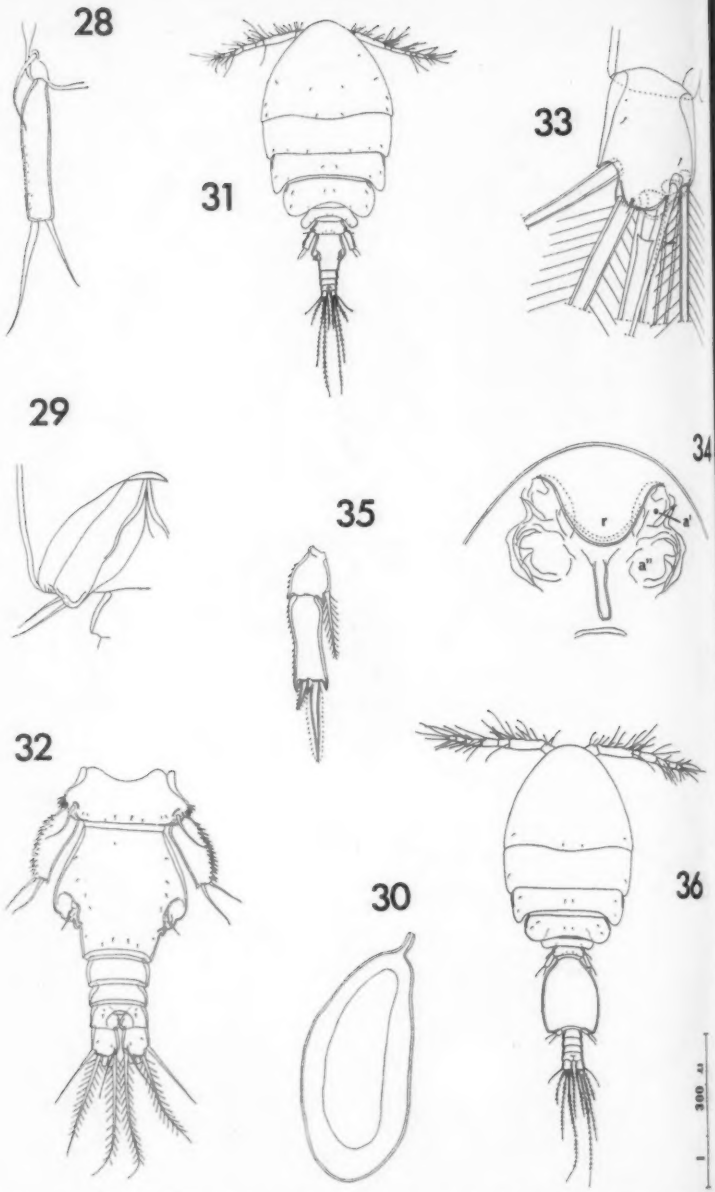
FIGURES 1–8.—*Lichomolgus organicus*, new species, female: 1, dorsal (A); 2, urosome, dorsal (B); 3, area of attachment of egg sac, dorsal (C); 4, caudal ramus, dorsal (D); 5, egg sac, dorsal (E); 6, rostral area, ventral (B); 7, first antenna, with two arrows indicating positions of aesthetes added in male, dorsal (F); 8, second antenna, posterior (F). (Capital letters=scale at which drawn; a'=first antenna, a''=second antenna, r=rostral area.)



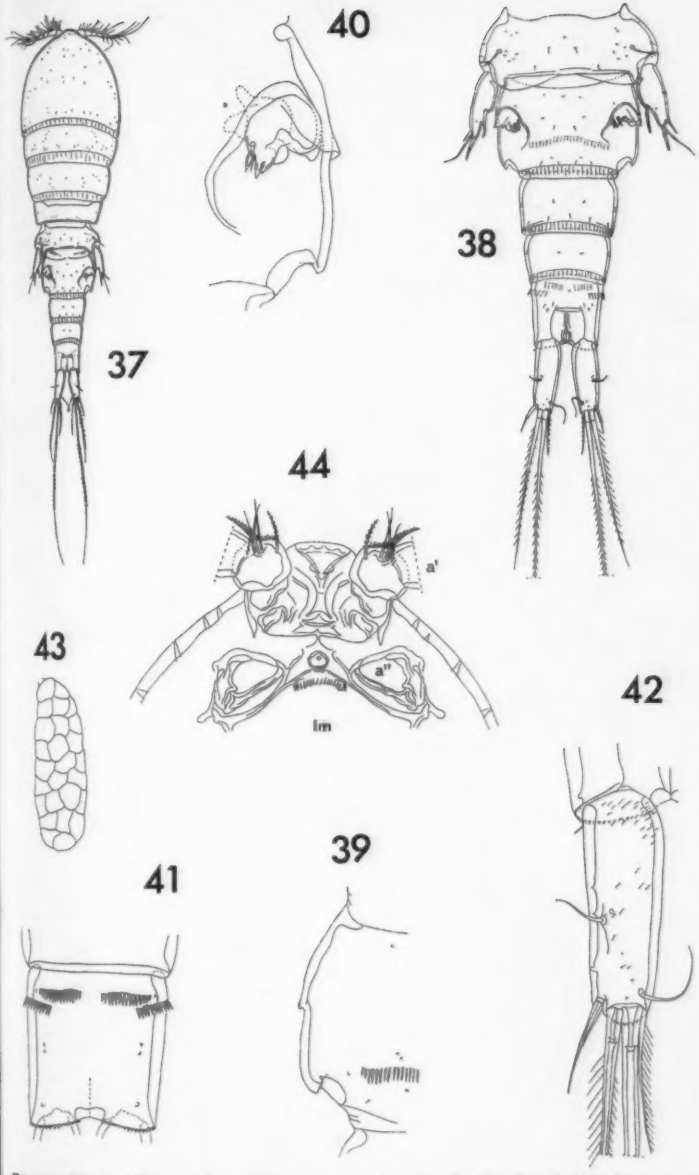
FIGURES 9–18.—*Lichomolgus organicus*, new species, female: 9, posterior part of labrum, with paragnaths indicated by dashed lines, ventral (G); 10, mandible, posterior (G); 11, first maxilla, posterior (G); 12, second maxilla, postero-inner (G); 13, tip of second maxilla, postero-inner (D); 14, maxilliped, posterior (G); 15, terminal segment of maxilliped, antero-inner (H); 16, postoral area between maxillipeds and leg 1, ventral (F); 17, leg 1 and intercoxal plate, anterior (F); 18, leg 2, anterior (F). (Capital letters=scale at which drawn; mxpd=maxilliped, P_1=leg 1.)



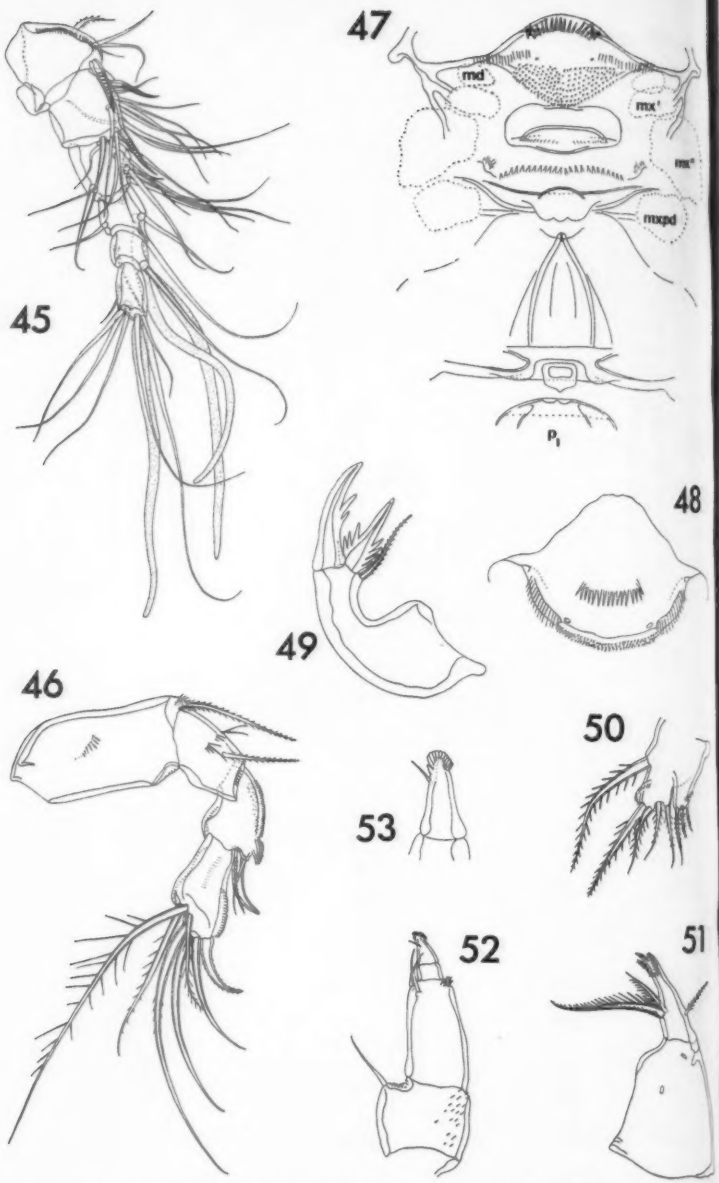
FIGURES 19–27.—*Lichomolgus organicus*, new species, female: 19, leg 3, anterior (F); 20, leg 4 and intercoxal plate, anterior (F); 21, leg 5, dorsal (D). Male: 22, dorsal (A); 23, urosome, dorsal (B); 24, caudal ramus, dorsal (C); 25, second antenna, anterior (F); 26, maxilliped, anterior (F); 27, endopod of leg 1, anterior (G). (Capital letters=scale at which drawn.)



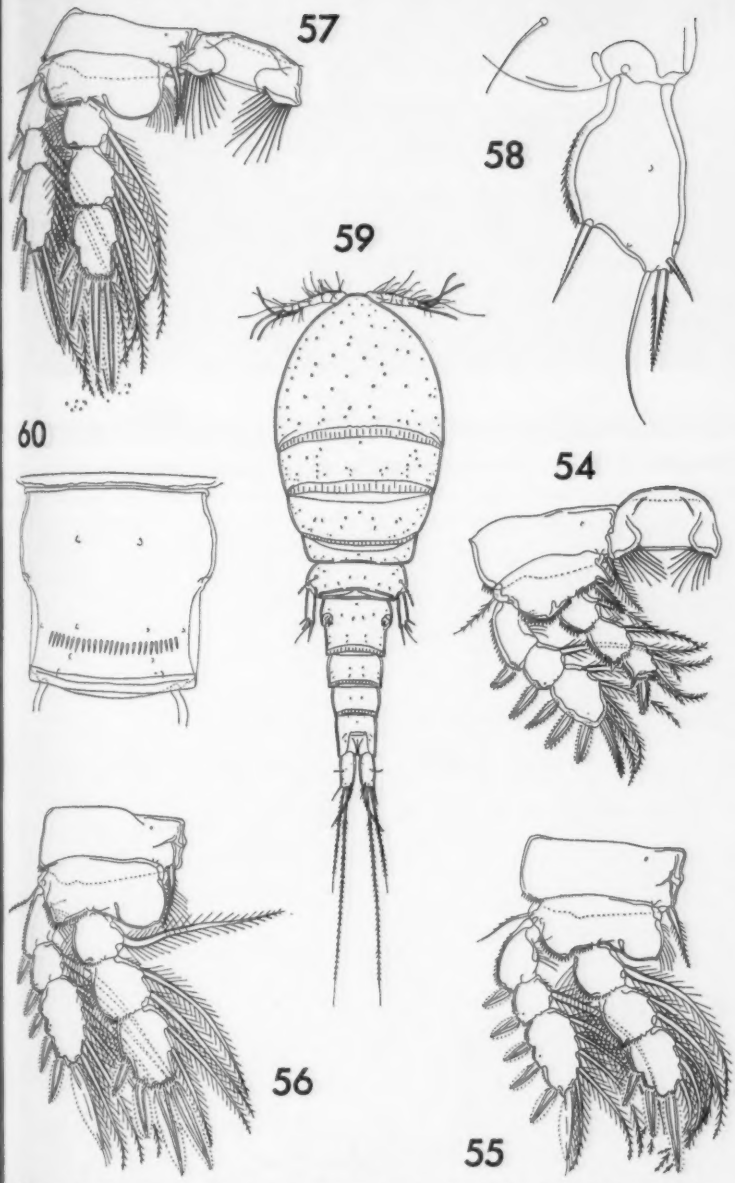
FIGURES 28–36.—*Lichomolgus organicus*, new species, male: 28, leg 5, dorsal (D); 29, leg 6, ventral (G); 30, spermatophore, inside male, ventral (F). *Lichomolgus conjunctus*, new species, female: 31, dorsal (A); 32, urosome, dorsal (B); 33, caudal ramus, dorsal (C); 34, rostral area, ventral (B); 35, endopod of leg 4, anterior (F). Male: 36, dorsal (I). (Capital letters=scale at which drawn; a'=first antenna, a''=second antenna, r=rostral area.)



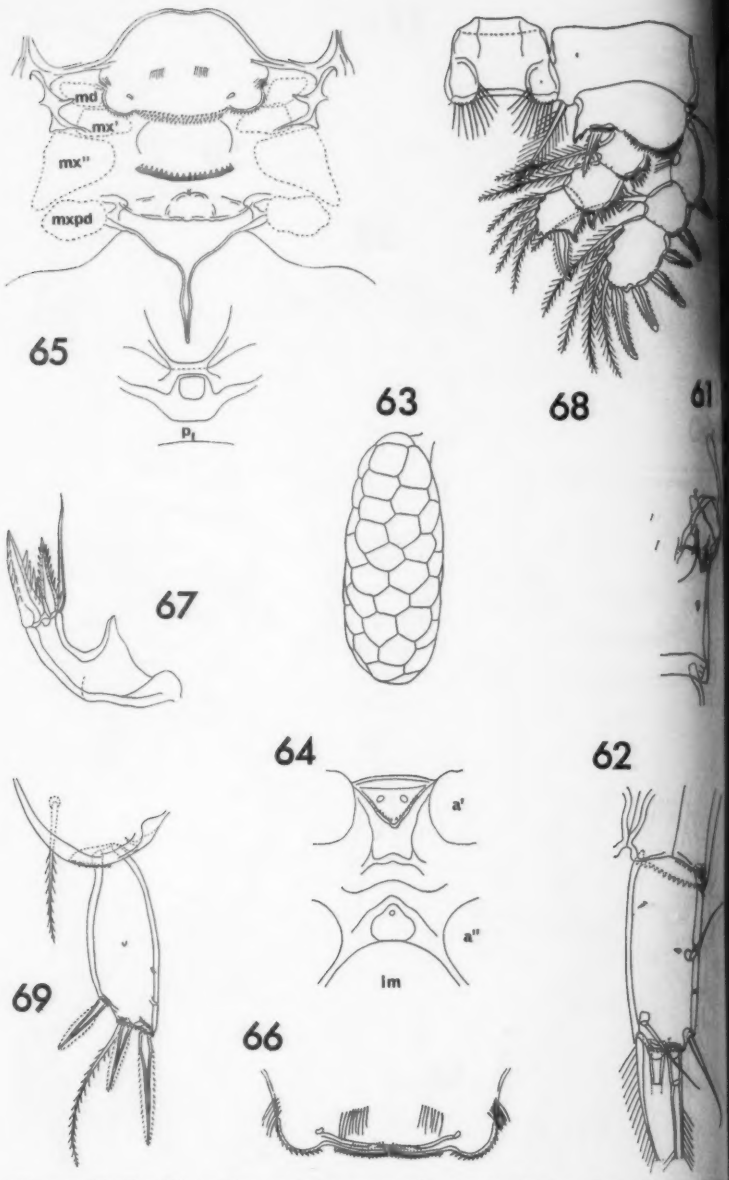
FIGURES 37–44.—*Hippomolgus latipes*, new species, female: 37, dorsal (A); 38, urosome, dorsal (E); 39, right side of genital segment, ventral (F); 40, area of attachment of egg sac, dorsal (G); 41, anal segment, ventral (F); 42, caudal ramus, dorsal (G); 43, egg sac, lateral (I); 44, rostral area, ventral (F). (Capital letters=scale at which drawn; a'=first antenna, a''=second antenna, lm=labrum.)



FIGURES 45–53.—*Hippomolgus latipes*, new species, female: 45, first antenna, dorsal (G); 46, second antenna, posterior (D); 47, oral and postoral areas, with labrum erected, ventral (G); 48, labrum, ventral (G); 49, mandible, posterior (C); 50, first maxilla, anterior (D); 51, second maxilla, anterior (D); 52, maxilliped, anterior (D); 53, last segment of maxilliped, ventral (H). (Capital letters=scale at which drawn; md=mandible, mx'=first maxilla, mx''=second maxilla, mxpd=maxilliped, p_1=leg 1.)



FIGURES 54–60.—*Hippomolgus latipes*, new species, female: 54, leg 1 and intercoxal plate, anterior (F); 55, leg 2, anterior (F); 56, leg 3, anterior (F); 57, leg 4 and intercoxal plate, anterior (F); 58, leg 5, lateral and outer (G). *H. cognatus*, new species, female: 59, dorsal (I); 60, genital segment, ventral (F). (Capital letters=scale at which drawn.)



FIGURES 61–69.—*Hippomolgus cognatus*, new species, female: 61, area of attachment of egg sac, dorsal (G); 62, caudal ramus, dorsal (D); 63, egg sac, lateral (E); 64, rostral area, ventral (G); 65, oral and postoral areas, ventral (G); 66, free edge of labrum, ventral (D); 67, mandible, posterior (C); 68, leg 1, anterior (G); 69, leg 5, ventrolateral (D). (Capital letters=scale at which drawn; md=mandible, mx'=first maxilla, mx''=second maxilla, mxpd=maxilliped; P_1=leg 1, a'=first antenna, a''=second antenna, lm=labrum.)

U.S. GOVERNMENT PRINTING OFFICE: 1967